

CLAIMS

1. Cyclic method for separating at least one chemical element E1 from at least one chemical element E2 present in a same aqueous solution, each cycle of said method comprising the following steps:

a) co-extracting from said aqueous solution the elements E1 and E2 by bring said solution into contact with a liquid organic phase containing a first extractant in an organic diluent, said first extractant being suited to causing the migration of said elements into said organic phase;

b) adding to the organic phase a second extractant suited to selectively retaining the element(s) E2 in said organic phase during step c):

c) selectively stripping the element(s) E1 from the organic phase, by bringing said organic phase into contact with an aqueous solution suited to causing the migration of said element(s) from said organic phase towards said solution;

d) selectively stripping the element(s) E2 from the organic phase, by bringing said organic phase into contact with an aqueous solution suited to causing the migration of said element(s) from said organic phase towards said solution;

e) separating the first and second extractants present in said organic phase at the end of step d) from each other with a view to using them again in the following cycle.

2. Method according to claim 1, in which the first and second extractants are separated from each other by aqueous solubilisation of one of said extractants.

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3. Method according to claim 1, in which the first and second extractants are separated from each other by distillation of one of said extractants.

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4. Method according to claim 1, in which the first and second extractants are separated from each other by cryogenic solidification of one of said extractants.

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5. Method according to claim 1, in which the first and second extractants are separated from each other by demixing two non-miscible organic phases.

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6. Method according to claim 1, in which the first and second extractants are separated from each other by an operation leading to the removal of the second extractant from the organic phase and maintaining the first extractant in said phase.

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7. Method according to claim 6, in which the first and second extractants are separated from each other by aqueous solubilisation, distillation or cryogenic solidification of the second extractant.

8. Method according to claim 6 or claim 7, in which the organic phase is subjected, after removing the second extractant, to a purification treatment.

5 9. Method according to claim 8, in which the second extractant is back-extracted in a fraction of the organic phase purified by bringing said fraction into contact with an aqueous solution of said extractant.

10 10. Method according to any of the previous claims, in which the first and second extractants are chosen from the group comprising solvating extractants, anion exchange extractants and cation exchange extractants.

15 11. Method according to any of claims 1 to 10, in which the first or second extractant is chosen from the group comprising tri-n-butylphosphate, malonamides, trialkylphosphine oxides, carbamoylphosphine oxides, tri-isobutylphosphine sulphides, carbamoylphosphonates, 20 substituted pyridines and 2,2'-dibenzimidazoles.

12. Method according to any of claims 1 to 10, in which the first or second extractant is chosen from the group comprising quaternary ammoniums, secondary amines, 25 tertiary amines and trialkyl guanidines.

13. Method according to any of claims 1 to 10, in which the first or second extractant is chosen from the group comprising carboxylic acids, phosphoric acids,

phosphonic acids, phosphinic acids, thiophosphoric acids,
thiophosphonic acids, thiophosphinic acids,
thiophosporous acids, sulphonic acids, hydroxamic acids,
substituted 8-hydroxyquinolines, β -diketones and β -
5 hydroxyoximes.

14. Method according to any of the previous claims,
in which the element(s) E1 are chosen from the group
comprising the minor actinides, whereas the element(s) E2
10 are chosen from the group comprising the lanthanides.

15. Method according to claim 14, in which the
elements E1 and E2 are co-extracted from an aqueous
solution having a pH at the most equal to 1 and the first
15 extractant is a solvating extractant.

16. Method according to claim 15, in which the
solvating extractant is a malonamide, in particular
dimethyldibutyltetradecyl malonamide (DMDBTDMA) or
20 dimethyldioctylhexylethoxymalonamide (DMDOHEMA).

17. Method according to claim 15 or claim 16, in
which the second extractant is a cation exchange
extractant.

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18. Method according to claim 17, in which the
cation exchange extractant is a phosphoric acid, in
particular bis-(2-ethylhexyl)phosphoric acid (HDEHP) or
bis-(1,3-dimethylbutyl)phosphoric acid (HBDMBP).

19. Method according to any of claims 14 to 18, in which the element(s) E1 are stripped from the organic phase by bringing said organic phase into contact with an aqueous acid solution, of pH higher than 1, and containing one or several complexing agents chosen from among the group comprising carboxylic acids, hydroxycarboxylic acids, polyaminocarboxylic acids, dithiophosphonic acids, sulphonic acids, amines and hydrophilic polyazines.

20. Method according to any of claims 14 to 19, in which the element(s) E2 are stripped from the organic phase by bringing said organic phase into contact with an aqueous solution of nitric acid of molarity between 0.1 and 1.

21. Method according to any of claims 14 to 20, in which step e) of each cycle comprises the following operations:

- selectively stripping the second extractant from the organic phase;
- purifying the organic phase thus unloaded of the second extractant; and
- back-extracting the second extractant in a fraction of the organic phase thus purified, said fraction representing around 5 to 25% by volume of the volume of the organic phase at the end of step d).

22. Method according to claim 21, in which the second extractant is stripped from the organic phase by bringing said organic phase into contact with an aqueous solution, of pH higher than 3, containing a strong base and, if necessary, a weak hydrophilic acid.

23. Method according to claim 21, in which the organic phase is purified by bringing it into contact with an aqueous solution of a strong base, of pH higher than 8.

24. Method according to claim 21, in which the second extractant is back-extracted in the fraction of organic phase by bringing said fraction into contact with an aqueous acid solution, of pH less than or equal to 3.

25. Method according to any of claims 14 to 24, in which one separates americium and curium from lanthanides.

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